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Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research

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ABSTRACT

Interdisciplinary and multi-stakeholder research is increasingly being promoted and implemented to enhance understanding of global environment change, identify holistic policy solutions, and assist implementation. These research activities are social processes aiming to enhance the exchange and translation of knowledge. Emphasis on the design and management of knowledge exchange is increasing, but learning about how to do this better is hampered by lack of conceptual development and appropriate methods to evaluate complex and multifaceted knowledge exchange processes. This paper therefore develops principles for the evaluation of knowledge exchange in interdisciplinary, multi-stakeholder environmental change research. The paper is based on an analysis of 135 peer-reviewed evaluations of knowledge exchange from diverse disciplines. The results indicate strong relationships between the field of study (e.g. health care, environmental management), the way knowledge and knowledge exchange were conceptualised and implemented, the approach used for the evaluation, and the outcomes being evaluated. A typology of seven knowledge exchange evaluations is presented to guide discussions about the underlying assumptions of different approaches to knowledge exchange and its evaluation. Five principles for knowledge exchange evaluation are also identified: (i) design for multiple end users; (ii) be explicit about why a particular approach to knowledge exchange is expected to deliver its outcomes; (iii) evaluate diverse outcomes; (iv) use evaluations as part of the process of delivering knowledge exchange; and (v) use mixed methods to evaluate knowledge exchange. We conclude that a catch-all approach to evaluation is neither appropriate nor desirable. Instead, approaches that focus on understanding the underlying processes of knowledge exchange, assess the relative contribution of other factors in shaping outcomes in addition to knowledge exchange, and that involve multiple stakeholders in implementing evaluations, will be the most appropriate for evaluating knowledge exchange in interdisciplinary global environmental change research.

1. Introduction

Knowledge about environmental and societal challenges has significantly improved understanding of the need to instigate change towards more sustainable human activity. However, simply providing more and better information and predictions of global environmental change is not enough (Fischer et al., 2012). More effort is needed to understand how to create change, implement research, and facilitate new ways of thinking (Fischer et al., 2012; O'Brien et al., 2013). How knowledge is integrated and perceived is crucial in this regard. Integration and perceptions of knowledge affect how problems are identified and framed, the capacity for generation of innovative and practical solutions, the relevance of outcomes to policy and the extent of participation in learning (Bracken and Oughton, 2013; Juntti et al., 2009; Raymond et al., 2010; Reed, 2008).

While much more work is needed to bridge disconnections between research and practice, there are signs that the way research is being conducted, facilitated, and funded, and the relationship between science and society is changing (e.g. Funtowicz et al., 2000; Nowotny et al., 2001; Planet Under Pressure, 2012). Traditional assumptions of researchers as the sole producers of knowledge are

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increasingly being supplanted by activities that include multi-way interaction and co-production of knowledge between researchers, decision-makers and other beneficiaries of science (Francis and Goodman, 2011; Funtowicz and Ravetz, 1993; Planet Under Pressure, 2012; RCUK, 2009). Increased demands for publicly funded research to be able to justify its activities by demonstrating economic and social impact (ESRC, 2009, 2012) are resulting in more directed research programmes, greater activities to enhance the sharing of knowledge, and mechanisms to incentivise researchers to find ways of generating policy- and practice-related 'impact' from their research (DFID, 2013; Phillipson et al., 2012). This reflects recognition of the value of different forms of knowledge (e.g. local and scientific) and inclusion of diverse voices to find more innovative solutions and ensure research is relevant, valid and practical (Connick and Innes, 2003; Raymond et al., 2010). These changes are particularly important for environmental change research where there is a need for cross-fertilization of perspectives to address challenging and multi-faceted problems (Kates et al., 2001; Norgaard, 2004). Yet the opportunities also pose significant challenges for researchers who need to juggle demands for their work to be both inclusive and robust in the eyes of their academic peers.

Overall, awareness is increasing about the importance of research fields that study the process of research itself. Such fields include implementation science, knowledge translation, knowledge management and research impact. These fields are both *activities* aiming to encourage implementation and practice, and *research* that aims to understand the processes shaping the sharing and integration of knowledge. One area gaining particular prominence is knowledge exchange. Knowledge exchange is a broad concept defined as "a process of generating, sharing, and/or using knowledge through various methods appropriate to the context, purpose, and participants involved" (Fazey et al., 2013). It encompasses a range of concepts such as co-production, transfer, storage, transformation, integration and translation of knowledge and social learning, with each concept having different implied meanings (Fazey et al., 2013).

Knowledge exchange is relevant to most areas of research, drawing on insights from diverse fields, including adaptive co-management, participation, stakeholder engagement, and community based conservation. It can be both formal or informal, from co-management and co-production of research, community-based or collaborative management, knowledge brokering, management of knowledge sharing systems in organisations or to support disaster planning, community communication and knowledge transfer, the translation of research for practice, health education programmes or policy-maker forums. Processes to enhance knowledge exchange may therefore range from small scale one off interventions that involve didactic teaching to large scale community engagement or management programmes.

While knowledge exchange has always occurred in some form in applied research, and continues to do so informally through diverse mechanisms and processes in which researchers engage with others (e.g. through teaching, the sharing expertise with volunteers or those working in practice, or the social interactions in the development of policy), there have been significant developments in the research environment that are not simply related to a change in rhetoric. First, there is a greater emphasis on the *importance* of being more explicit about enhancing knowledge exchange in ways that are more participatory or that put researchers on a more equal footing with other stakeholders, such as during the co-production of research (Fazey et al., 2013; La Peyre et al., 2001; LWEC, 2012; Mauser et al., 2013). Second there is increasing emphasis on explicitly *designing* knowledge exchange to enhance the way in which engagement and exchange occurs (LWEC, 2012). This can increase emphasis on how a particular

approach is expected to deliver its intended outcomes, rather than automatically assuming that it will do so. These recent shifts do not necessarily mean that changes in practice have occurred, and in most cases ways of working between academia and other sectors are still traditional and hierarchical and there is much scope for using a wider range of approaches (Davies and Powell, 2012). However, the discourse about the role of research and how it is done is changing, providing space for more innovative and potentially more fruitful mechanisms of the sharing of knowledge and cross-sectoral engagement and learning.

Perhaps not surprisingly then, knowledge exchange is increasingly being recognised as a research field in its own right (Straus et al., 2011). Such research aims to understand the social processes involved in knowledge exchange that enhance the impact of research on policy and practice. A research agenda for knowledge exchange, developed by eliciting the expertise of researchers and practitioners, found that while related activities were increasingly being used during and after research in environmental fields, there was a particular need for: (1) a better understanding of the processes and mechanisms involved and (2) conceptual and methodological development for evaluating knowledge exchange (Fazey et al., 2013). These two areas are interrelated. Understanding process requires suitable evaluation methodologies, while improving evaluation requires understanding of the process to determine what should be evaluated and which methodologies are most appropriate. Despite some notable exceptions (e.g. Meagher et al., 2008; Phillipson et al., 2012), there are limited examples of process-oriented impact studies or large scale evaluations of knowledge exchange in multi-stakeholder and interdisciplinary endeavours (Pentland et al., 2011; Phillipson et al., 2012; Plummer and Armitage, 2007).

This paper aims to develop overarching principles for evaluating knowledge exchange in interdisciplinary and multi-stakeholder environmental change research. While insightful reviews of evaluations of research impact have already been conducted (Boaz et al., 2009), this paper specifically focuses on knowledge exchange evaluations. The key objectives are to: (1) provide an overview of different kinds of knowledge exchange evaluations and what they evaluate; (2) establish an empirically based typology of knowledge exchange evaluations; (3) determine how the way knowledge exchange is conceptualised influences approaches to evaluation; and (4) critically assess the relevance of different approaches to knowledge exchange evaluation to interdisciplinary research programmes relevant to global environmental change. The paper is based on analysis of 135 peer reviewed evaluations of knowledge exchange.

We first describe our methodology (including conceptual foundations), then the research results. We conclude with a discussion of the implications of the findings for evaluating knowledge exchange in complex research processes, and set out five overarching principles to guide the design of knowledge exchange evaluations. The paper is significant for three reasons. As far as we are aware, it is the first to: provide an empirically based typology of evaluations generally; analyse different kinds of knowledge exchange evaluations; and establish a set of principles for knowledge exchange evaluation for global environmental change research. The outcomes of the paper will be of relevance to researchers and practitioners from diverse backgrounds interested in learning from existing projects and programmes and to improve the design of knowledge exchange processes.

2. Methodology

2.1. Three key aspects of knowledge exchange evaluation

There are many definitions and uses of evaluation (Chapman et al., 2007; European Communities, 2006; Shufflebeam and

Shinkfield, 2007). Generally, however, evaluation involves determining value, significance, worth or condition through a process of appraisal (Chapman et al., 2007). It is applied social science research for answering policy-oriented questions, and for assisting decision-making (Rossi, 2004). Evaluations can be conducted at different scales: e.g. individual projects; programmes that encompass a suite of projects aiming to achieve a higher order goal; and strategies that involve complex interventions (e.g. the economic development of a whole country) (European Communities, 2006).

Evaluation methodologies are developed for specific needs and circumstances and are influenced by different epistemological and ontological positions on how research should be conducted. To understand different evaluation methodologies for knowledge exchange, it is therefore necessary to understand the relationships between three key aspects of knowledge exchange evaluation: the way knowledge exchange is conceptualised and conducted, the methods used to undertake an evaluation, and the outcomes of knowledge exchange being evaluated. We first explain these three key aspects, which are the basis of the questions used to survey the research papers. We then explain how the different knowledge exchange evaluations were selected for our research and how the data were collected and analysed.

2.1.1. The way knowledge exchange is conceptualised and implemented

Different kinds of knowledge exchange activities require different methods of evaluation. To understand evaluation of knowledge exchange and establish a typology of knowledge exchange evaluation, it is therefore necessary to consider the way knowledge exchange is conceptualised and how it is implemented. Knowledge exchange methods are diverse, ranging from simple transfer of information (e.g. presentations), teaching, and management of knowledge, through to computerised knowledge management systems (Raman et al., 2011; Warner et al., 2011), and wider, complex multi-way interactions, such as the social processes involved in adaptive co-management (Leys and Vanclay, 2011; Sheppard et al., 2010). They can also occur in formal organised, designed and intentional ways or through informal implicit processes (e.g. much of knowledge exchange is informal and occurs via peer-peer social learning and social media).

Importantly, the way knowledge exchange is conducted is strongly influenced by the way knowledge exchange is conceptualised (e.g. sharing or transfer of knowledge), which in turn is influenced by epistemological beliefs. These are the beliefs a person holds about what knowledge is (e.g. are there knowable facts or is the social world constructed through subjective experience?) or how they come to know something (e.g. to what extent is knowledge justified through evaluation of 'evidence' or personal experience?) (Hofer, 2000). For example, the belief that knowledge is something that can be passed on to others in inert form tends to come from positivist perspectives and is usually related to didactic and structured approaches to knowledge exchange where one-way exchanges (e.g. teaching or use of particular media such as leaflets) are the norm (e.g. Kirshbaum, 2008; Stringer et al., 2011). More subjectivist perspectives believe that knowledge is dependent on an individual's perspective or understanding of knowledge. Subjectivist perspectives acknowledge existence of multiple kinds and understandings of knowledge which are shaped and constructed by experience, culture and background. Such views tend to result in knowledge exchange activities that encourage mutual learning through multi-stakeholder interactions, and that are not simply linear producer-to-end user activities (e.g. Granek and Brown, 2005; Heylings and Bravo, 2007). Understanding knowledge exchange evaluation methodologies therefore needs to take into account both how knowledge is understood and how knowledge exchange is implemented.

2.1.2. Methods used for evaluation

Methods of evaluation are diverse. They may be inductive or deductive, can involve collection and analysis of quantitative or qualitative data, be conducted as experiments, comparisons or case studies, may rely on external or internal evaluators, and differ in the length of time during which knowledge exchange is evaluated. There are two broad typologies of particular relevance to interdisciplinary global environmental change research. This is whether evaluations are either summative or formative or participatory or non-participatory (Fetterman and Wandersman, 2005; Scriven, 2004).

Summative evaluations aim to provide validation at the end of projects about the merits or success of knowledge exchange activities. They are often used when there is a strong emphasis on accountability and frequently use quantitative measures of success (McWilliam et al., 2003; Sheppard et al., 2010). Summative approaches, however, can have limited capacity to understand the often fluid and dynamic nature of knowledge exchange as they focus more on the outcomes rather than the processes that led to them. Further, while summative evaluations may provide 'rich and useful' information, the insights from them are often locked up in a report and difficult to access (Roux et al., 2010). Formative evaluations, in contrast, aim to enhance reflection to improve and refine project activities by embedding evaluation in activities that occur throughout a project cycle (e.g. Bowen et al., 2005; Bowen and Martens, 2006). Formative evaluations provide the basis for an adaptive approach to implementing knowledge exchange activities enabling flexibility in implementation as new insights about knowledge exchange emerge (Allan and Stankey, 2009; Roux et al., 2010; Salafsky et al., 2001).

Evaluations can also be either participatory or non-participatory. Participatory evaluations involve multiple stakeholders in setting questions, identifying indicators and collecting and interpreting data (Zukoski and Luluquisen, 2002). Participatory approaches provide valuable opportunities for sharing perspectives, challenging or reducing dominance of particular knowledge types or ways of knowing, and flattening hierarchies that may constrain knowledge production and learning (Fetterman and Wandersman, 2005; Zukoski and Luluquisen, 2002). There are also different degrees of participation with some participatory evaluation approaches specifically designed to break down distinctions and power inequities between knowledge 'producers' and 'end users'. Such evaluations are called 'empowerment evaluations' and involve close collaboration of stakeholders prior to implementation of a knowledge exchange process (Fetterman and Wandersman, 2005). Participation approaches recognise that those who wield knowledge that is socially accepted have considerable power in shaping outcomes of research or practice. Participatory evaluations are usually formative. They are more akin to the 'adaptive co-management' of knowledge exchange where diverse stakeholders or participants learn about and engage more deeply with knowledge exchange compared to the 'adaptive management' of knowledge exchange where iterative learning occurs, but where the learning is mostly confined to those managing knowledge exchange. Formative and participatory approaches that engage multiple-stakeholders in doing evaluations directly contribute to the process of knowledge exchange. They can therefore be part of the knowledge exchange strategy itself, increasing ownership, responsibility and motivation for delivering knowledge exchange (Fetterman and Wandersman, 2005; Zukoski and Luluquisen, 2002).

2.1.3. Outcomes evaluated

Approaches and methods of evaluation also depend on what is to be evaluated. There are four broad possible outcome dimensions typically found in the literature. First, the knowledge exchange

may result in changes in understanding, e.g. increased knowledge, change in attitudes, and changes in thinking (Kirshbaum, 2008). Second, there can be changes in practice or policy (Warner et al., 2011). Third, actual impacts of changes in practices/policies can be evaluated, such as improvements in business performance or human or ecological health (e.g. Crawford et al., 2010; Gross and Lowe, 2009). Finally, a diversity of knowledge exchange process-oriented outcomes can be assessed. These can include how knowledge exchange was conducted (e.g. leadership, methods used, communication patterns) and the quality of the processes (e.g. quality of information, levels of engagement, cost effectiveness, barriers) (e.g. Heylings and Bravo, 2007; Kuper et al., 2009). Different outcomes require different methods, such as surveys and interviews to evaluate changes in understanding and process-based outcomes and quantitative data for performance (e.g. environmental health).

2.2. Identifying and selecting research papers

To account for the multiple interpretations of knowledge exchange, we identified published accounts of evaluations of knowledge exchange using key terms to search Scopus (2012) (Table 1). While these terms have been intentionally broad to encompasses both formal and informal processes, focusing on published evaluations means that the study is likely to be skewed towards formal knowledge exchange 'interventions'. Nevertheless, the breadth of papers that have been identified did include very diverse kinds of studies and contexts (see Appendix 1 in supplementary material for titles of all papers).

Inclusion of papers was determined through three stages. First, the searches included all papers published up to and including the year 2011 classed as 'article review', 'article' and 'article in press'. This identified 6094 initial papers. In the second stage, papers relating to computer science were excluded because of the high number of studies on technical aspects that were deemed outside the immediate interest of global change research. All other fields were included given that global change is inherently interdisciplinary and that cross-fertilization of ideas about knowledge exchange evaluation has so far been limited (Kothari et al., 2011b; Miller et al., 2008). Titles and abstracts were read to identify papers that directly discussed evaluation approaches or conducted evaluations. Those that only briefly mentioned evaluation were rejected. Seven papers not written in English, French or German (i.e. languages familiar to the reviewers) were also rejected, resulting in a total of 191 papers. In the third stage, review papers were omitted, resulting in 135 papers that specifically described an empirical knowledge exchange evaluation (125 papers) or a detailed proposal of such an evaluation (10 papers).

2.3. Data collection and analysis

A survey was conducted by reading the 135 papers and answering key questions for each paper. To establish survey questions, four of the authors (IF, LB, JM, MP) each read the same initial subset of 30 papers. The 30 papers were chosen randomly from papers identified with different search terms (Table 1), but with the overall proportion of the subset being equivalent to the proportion of terms in the 135 papers. Questions aimed to characterise different aspects of the three inter-related areas described above (knowledge exchange activities, methods for the evaluation, and outcomes assessed). Questions were then identified and discussed by the four primary reviewers to ensure consistency in interpretations of questions and data collection in later stages. Given the diversity of types of knowledge exchange and evaluations, questions were kept mostly open-ended to enable a more complete set of categories to emerge inductively after the reading of all papers had been completed.

All papers were then reviewed (including a re-review of the 30 initial papers) by three reviewers (LB, JM, MP). Answers to survey questions were analysed using axial coding to identify categories for each question. Some of the variables emerging from the questions were aggregated, resulting in a final list of variables for each paper, each with a set of sub-categories (Tables 2–4). In most cases papers were assigned to a single category for a particular question. For three questions (approach used to do knowledge exchange, tools used for data collection, dimensions of outcomes evaluated) papers were assigned to multiple categories for a single variable. For the purposes of analysis, these categories were treated as individual variables with a presence/absence value for each paper.

To identify a typology of knowledge exchange evaluation a non-linear a dimension-reduction technique, canonical correlation analysis (CCA), was conducted using SPSS (version 19, 2012). Only the 125 papers describing actual evaluations were used as they had a complete set of data for all questions. CCA involves dividing the survey questions into different sets. For this analysis, four sets of categories were used to ensure that the large number of presence/absence variables did not give disproportionate weight to the questions. The variables 'research field' and 'search term' were not included in the analysis.

CCA produces two key results. Firstly it reduces the multi-dimensional survey responses to object scores in two independent dimensions for each paper. These scores/dimensions represent similarities between the research papers based on how similar responses are for each paper to each of the survey questions. This enables exploration of which papers are most closely related. Secondly CCA calculates 'centroid' scores for each of the categories that make up the answers to the survey questions. The centroid scores represent similarities between the categories (e.g. whether knowledge brokers are associated with quantitative approaches). This enables exploration of how characteristics of knowledge exchange and evaluation are related, and the identification of a typology of knowledge exchange evaluations by plotting the category centroids on a two-dimensional graph. The values of the object scores for each paper and the centroid scores for each category are located on the same dimensions. This enables broad comparisons of whether the different fields of research are associated with particular types of evaluation.

Table 1
Search terms used and number of studies identified in each stage of the research process.

Search term	Stage 1: identification	Stage 2: inclusion	Stage 3: inclusion
evaluat* AND "knowledge transfer"	534	56	41
evaluat* AND "knowledge shar*"	488	29	24
evaluat* AND "knowledge exchange"	119	11	8
evaluat* AND "knowledge translation"	214	17	12
evaluat* AND "knowledge management"	4576	49	27
evaluat* AND "co-produc*" AND knowledge	30	3	1
evaluat* AND "co-management"	133	26	22
Total	6094	191	135

Table 2

Variables and related categories generated from axial coding for the type of knowledge exchange. Each paper is entered into a single category for a variable unless otherwise stated. The last four columns are the percentage of papers in different research fields and the percentage of all papers in a specific category. Research fields are: E = *Education* (educational practices, management of educational institutions, $n = 11$); EM = *environmental management* ($n = 26$, conservation, conservation education, natural resource management); HC = *Health care* ($n = 59$, clinical health care, health policy, preventive health care and counselling); OM = *Organisational management* (management of businesses and other organisations, $n = 29$); O = *Other* ($n = 10$).

Variable	Categories	Description of category	E	EM	HC	OM	O	All
Extent of theory explanation	1	None	0	35	20	0	10	16
	2	Little, mentions theory in a few sentences	9	27	44	21	30	32
	3	Very explicit and more extensive description	91	38	36	79	60	52
Who is knowledge exchanged between?	R <> R, 1 or 2 way	*R = Researcher* *PM = Policy maker/practitioner*: Person with a degree of power or influence over others, e.g. politician, doctor, manager *WS = Wider stakeholders*: People with less influence, e.g. community residents, patients, company employees *1 way*: Knowledge is exchanged in only 1 direction *2 way*: Knowledge is exchanged mutually between participants	0	0	3	0	10	2
	R > PM, 1 way		0	0	20	0	10	10
	R <> PM, 2 way		9	4	31	0	10	16
	R > WS, 1 way		0	0	5	0	20	4
	R <> WS, 2 way		0	4	2	0	0	1
	PM <> PM, 1 or 2 way		9	0	10	0	10	6
	PM > WS, 1 way		27	4	12	0	10	9
	PM <> WS, 2 way		0	46	5	3	0	12
	WS <> WS, 2 way		55	12	3	93	30	30
	R <> PM <> WS, 2 way		0	31	8	0	0	10
	Not specified		0	0	0	3	0	1
Approaches to KE								
Medium	Presence	Information is distributed using a medium, e.g. leaflet	9	4	32	21	10	21
Literature	Presence	Publication in peer-reviewed journals, prof. literature	0	0	8	0	0	4
Observation/replication	Presence	One party learns by observing another, e.g. copying of successful routines or guidelines	0	4	2	7	0	3
Teaching	Presence	One person or group teaches many others, e.g. presentation, lecture, training course	36	8	37	24	30	28
Knowledge broker	Presence	New knowledge/practice is distributed by one or several visits of a knowledge broker to another group/institution	0	0	12	3	0	6
Knowledge champions	Presence	"ambassadors" are trained in new practice or knowledge to distribute it further in their institution	0	4	7	0	10	4
Personal contact	Presence	One time, face to face personal contact	9	19	22	59	0	27
Group exchange	Presence	One time meeting of several persons to exchange knowledge, e.g. workshop, forum, conference	0	27	44	41	30	36
Working partnership	Presence	persons working together for extended time period on a specific project/policy	9	12	12	17	20	13
Stakeholder institutions	Presence	Institutions that contain representatives of different stakeholder groups concerning a certain area of policy	0	42	5	0	10	11
Network	Presence	Relationship between several people over extended time communication non-electronic, e.g. CoP, k. network	0	4	10	14	10	9
Electronic network	Presence	KE relationship between several people over extended time, communication electronic, e.g. online CoPs, forums or mail dialogues	27	4	19	34	20	20
KM system	Presence	Technical infrastructure/tool for knowledge management	27	0	0	31	20	10
KM	Presence	KE is not further specified than "knowledge management"	18	0	0	38	0	10
Co-management	Presence	KE is not further specified than "co-management"	0	35	0	0	0	7

3. Results

In general, papers exhibited a wide diversity of knowledge exchange approaches from different disciplinary fields (Tables 2–4): 35% of the evaluation methodologies consisted of a single case study of knowledge exchange; 52% provided a moderately detailed explanation of underlying theory about knowledge or knowledge exchange; and 31% were one-way exchanges (Table 2). Some evaluations used a comparison to improve understanding of the outcomes or process (26%), and only a small number had either a control, conducted an evaluation before and after the knowledge exchange process, or used a combination of both (19%, Table 3). Many evaluations did not aim to directly improve the knowledge exchange process (70%) and most were not participatory (85%, Table 3). A moderate proportion of papers examined: the outcome dimensions related to understanding/attitudes (47%); behaviour/ practices/policies (33%); and impacts of behaviour/practices/ policies (41%, Table 4). The majority evaluated some aspect of the process of knowledge exchange (73%, Table 4). The outcomes within each of the dimensions measured were extremely diverse

Table 3

Variables and related categories generated from axial coding for the type of evaluation. CACS = comparison of case studies (or of different approaches); B&A = data collection before and after knowledge exchange; KM = knowledge management; KE = knowledge exchange.

Variable	Categories	Description of category	E	EM	HC	OM	O	All
Study design	CACS	CACS, data collection only after or during	10	31	16	38	50	26
	CACS with B&A	CACS with B&A, with or without control	0	15	10	3	0	8
	B&A with control	One case study/approach and control with B&A	10	4	9	0	0	5
	B&A no control	Only one case study with B&A, no control	10	4	21	3	10	12
	One KE and control	One case study and control, data collection only after or during KE	20	4	0	0	0	2
	One KE only	One case study/approach, data collected only after or assessment of current situation	40	42	36	21	40	35
	Relationship with other variable	Investigates relationship between characteristics of KE and one or more other variable (e.g. business performance)	10	0	7	7	0	8
	Other	Other study design	0	0	7	7	0	5
Randomisation	Randomised	Randomised sampling	60	4	16	14	10	16
	Not randomised	Non-randomised sampling	40	96	84	86	90	84
Qualitative/quantitative	Quantitative	Data is analysed using quantitative statistical methods	60	31	42	59	20	43
	Qualitative	Data is analysed using qualitative methods	20	50	37	21	50	36
	Both		20	19	20	21	30	21
Intent of evaluation	Intent to improve	Evaluation is intended to improve the particular KE	10	35	36	21	33	30
	No intent	Evaluation is not intended to improve the KE	90	65	64	79	67	70
Evaluator	External evaluator	Evaluators are external to the project/institution	70	69	41	83	50	58
	Internal evaluator	Evaluators belong to the project/institution	20	31	53	0	50	34
	Both		0	0	3	14	0	4
	Not clear		10	0	3	3	0	3
Time of evaluation	During	Evaluation is conducted during the KE project	30	73	45	86	50	59
	End	Evaluation is conducted at the end of the KE project	70	23	55	7	50	39
	Both	Evaluation is conducted during and at the end	0	4	0	7	0	2
Degree of participation	Participatory	Evaluation is designed and conducted with full participation of relevant stakeholders	10	19	17	7	20	15
	Consultative	Stakeholders are consulted to some degree after evaluation has been designed	0	8	14	17	10	12
	None	Evaluation is designed without participation of stakeholders	90	73	69	76	70	73
Duration of KE	Less than 1 month	Time between start of KE and evaluation	30	4	14	0	30	11
	1–11 months		40	12	21	4	30	18
	1–2 years		0	15	24	7	0	15
	2–5 years		0	19	22	7	10	16
	More than 5 years		0	38	9	19	10	16
	Not specified		30	12	10	63	20	24
Tools for data collection								
Observation	Presence	Documentation while observing KE, e.g. participant observation, reflective diaries	10	27	26	14	30	23
Interviews	Presence	One to one interviews or conversations	20	46	40	31	60	39
Group interviews	Presence	Guided interviews with several people, e.g. focus groups	0	12	21	7	0	13
Surveys	Presence	Distribution of questionnaires, paper or electronically	70	38	55	76	50	57
Knowledge test	Presence	Formal test of participants knowledge, e.g. exam	20	0	12	0	10	8
Site visit	Presence	Visit of a community or institution participating in KE	0	4	5	0	0	3
Existing data	Presence	e.g. reports, activity records, meeting minutes;	0	27	24	3	10	17
System data	Presence	System data of electronic KE tool, e.g. user numbers	30	4	7	7	10	8
Literature	Presence	Peer-reviewed, grey or professional literature	0	12	5	3	0	5
Ecological assessment	Presence	Assessment of ecological health	0	19	0	0	0	4

Table 4

Variables and related categories generated from axial coding for the outcome dimensions that were evaluated.

Variable	Categories	Description of category	E	EM	HC	OM	O	All
Process	Presence	Includes evaluations of the nature and/or quality of the knowledge exchange process, i.e. how or how well knowledge is conducted	64	62	76	76	80	73
Understanding	Presence	Immediate effects, e.g. increased awareness, understanding or knowledge; attitude change; new relationships and structures;	45	35	63	24	60	47
Practice change	Presence	Behaviour, practice or policy change	9	35	49	14	20	33
Impacts of practice change	Presence	The long term impacts resulting from behaviour or policy changes, e.g. improved health or environmental protection	27	73	29	52	20	41
Other	Presence	Any other outcomes.	18	0	2	14	0	5

Table 5

Specific outcomes evaluated in research papers in four broad outcome dimensions. For each outcome, examples from the papers (paraphrased) are also given. The last four columns show the percentage of papers in different research fields and for all papers that evaluate a particular outcome. E = education; EM = environmental management; HC = health care; OM = organisational management; CoP = community of practice.

Dimension	Category and description	Examples	E	EM	HC	OM	All
Process	*Level of KM*: to what extent knowledge management is implemented; existence/absence of strategies	State of IT infrastructure and systems; openness of communication; level of organisational learning/sharing	9	0	0	38	9
	Satisfaction: participants satisfaction and experience of the KE process	Intention to re-attend; perceived quality and benefits of KE; are expectations met?	36	12	25	10	22
	Communication/relationships: what are the relationships or roles of the participants, how do they communicate and what is the quality of the relationships and communication?	Network characteristics (key players, density); actor organisation; resolution of conflicts; clear, relevant, timely, respectful communication; power structure in agreement	18	27	15	17	20
	Participation: how many stakeholders were enabled to participate, how much did participants engage in the KE	Number of councils involved; local acceptance and support; factors influencing attendance; number of registrations for website membership; level of activity in CoP	0	15	15	7	12
	Efficiency: (cost) efficiency of KE in achieving its aims and affordability	Cost of intervention to councils; perception of cost-effectiveness; risks of the knowledge transfer process for stakeholders involved	9	8	2	3	4
	Sustainability: sustainability of the setup of the KE or the participating institutions	Institutional sustainability; resilience of the governance system	0	12	2	0	3
	Quality of information content: quality of information exchanged	Clearness and relevance of information; perceived reliability of content	9	4	15	0	8
	Knowledge: characteristics of knowledge used in the KE and its sources	Types and sources of knowledge used in CoPs; the roles of science and traditional ecological knowledge in decision-making	0	4	7	0	4
	Methods of KE: methods that are used for KE by participants	Means of knowledge spread; presence/absence of a KE strategy	0	0	5	14	5
	Leadership: Degree, location and quality of leadership in the KE process	High level leadership; leadership style	0	12	2	7	5
	Functionality and effectiveness: Functionality, applicability or effectiveness of a KE approach or tool	Functionality of management committees; How well did the blueprint for the SEEI work?; effectiveness of tool	0	8	7	3	5
	Formal process: Quality/suitability of the formal rules and of the implementation of the KE process; suitability of surrounding conditions and support	Quality of facilitation, location and accessibility; clearly defined responsibilities; timing of meetings; existence of long-term management policy; quality of monitoring; existence of central government support; free, prior and informed consent of the Traditional Owners; quality of hardware capacities	18	31	22	7	19
	Barriers to KE: What barriers and challenges hinder the KE	Information accessibility and use barriers; limitations of co-administration	0	4	7	3	4
	Ways to improve KE: how could the KE process be improved	Steps and processes to facilitate interactive knowledge transfer	0	0	3	3	2
	Other	How the group members take up, process and use knowledge; quality of the evaluation system	9	19	15	17	15
Understanding	Increased knowledge, awareness or understanding	Mothers' knowledge of causes, symptoms and treatments of malaria; ecological awareness of students	0	19	51	17	36
	Skills: new skills learned by participants	Ability to create good questions as assessed by self, peers and teacher; personal research skill development	36	0	5	0	3
	Attitude and attitude change	Change in perceived feasibility and importance of smoking cessations; attitude towards plantation forestry industry	0	12	10	0	7
	Intention of behaviour change	Intentions to engage in CoP-building activities; commitment to act	9	4	12	0	7
	Confidence: increased confidence in participants	Self-efficacy of patients in speaking to doctors; feeling of greater security and equality as care giver	0	0	14	0	6
	Innovation: creation of innovations and new ideas	Quantity and quality of the ideas resulting from the creative process	0	0	2	3	1
	New structure: new networks or structures are set up, communication is improved	Shared understanding; consensus on the topic; fishing agreement in place; less intervillage conflict; communication and collaboration is increased; trust has increased between partners	9	19	20	14	18
	Provision of information: amount/quality of new information provided	Complete information	0	4	0	3	1
	Identification of further needs or action	Identified research gaps and research questions	0	0	3	0	1
	Symbolic/political use of knowledge		0	0	5	0	2
	Other	Induced reflection on educational choices and career decisions; organisational memory is increased	9	4	0	3	2

Table 5 (*Continued*)

Dimension	Category and description	Examples	E	EM	HC	OM	All
Practice/policy	Individual behaviour change	Reported practice on exercise and breast care; compliance with no-take zones	0	12	15	0	10
	Use of new technology or tool	Use of new medical charters or protocols in medical practice for diagnosis or therapy; use of technology by companies to produce new products or therapies	9	0	5	0	2
	Decisions made	Decisions about best way to collectively manage plantation forestry	0	8	0	0	1
	New evidence integrated into policy/strategy	Stroke strategies developed and integrated with existing provincial programmes	0	0	7	0	3
	Change in organisational process or decision making	Influence of stakeholders on research process; organisational processes and reporting quality are increased	0	12	7	3	6
	Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself	Establishing steering group; actual implementation of joint drip irrigation projects	0	4	2	0	2
	Further sharing of knowledge	Copying of the process on another island; recommendations to friends; impacts on other networks and committees at provincial levels	0	4	10	0	5
	Use of knowledge: Not further specified	Application and utilisation of research; use of new information in practice	0	4	14	10	9
	Other	Whether the provided information are used for the behaviour change; bridging research and practice	0	0	8	3	4
Impacts of practice/policy	Ecological health	Increase in cockle density in and close to no-take zones; forestation level change; land protected from development	0	46	0	0	9
	Social and economic welfare	Well-being (using proxy: financial viability; employment and infrastructure); economic diversification; economic efficiency (using proxy: household income)	0	15	0	0	3
	Social equity/participation	Community empowerment; perceived power to influence decision making; social equity (using proxies: Gender equality, participating proportion of minority, information-obtaining approach, equity of project participation, competition of project participation, satisfaction of project participation)	0	15	0	0	3
	Business performance	Business competitiveness; total factory performance; customer satisfaction	0	0	2	45	10
	Quality of health and health care	Proportion of subjects off benefits (back to work) after 7 days; student health (using proxy: student absenteeism rates); quality of public health policies and programmes	0	0	19	0	8
	Capacity built	Increase of the capacity to take sustainable actions for health promotion as well as the strength and comprehensiveness of health promotion capacities	0	8	5	3	4
	Benefits for stakeholders involved	Outcomes of the collaboration for the company; benefits of CoP membership for CoP members; relevance of results for stakeholders	9	4	2	3	4
	Other	ISO 9000 certification by given deadline; resilience of human bear system (proxy: institutional change in KE); external awards	18	27	3	14	12
	Correlation of factors	Perceived impact of adoption of tool on company performance; correlation of the conditions identified with successful co-management in the literature with the perceived success of co-management	0	8	0	21	6

(Table 5): 36% of all papers evaluated only one of the 4 areas, 34% evaluated two of the four areas, 24% evaluated three of the four areas and only 6% evaluated all four areas.

3.1. Types of knowledge exchange evaluation

The analysis identified seven key types of knowledge exchange evaluation based on associations between the characteristics (i.e. specific categories in Tables 2–4) of how knowledge exchange is conceptualised, implemented and evaluated. The CCA analysis explained 71% of the variation in the data; 36% explained by dimension 1, and 35% from dimension 2. This suggests that associations between characteristics was strongest between sets 1–3 given that the loss of fit was greatest for set 4 (i.e. different tools used for data collection) in both dimensions (Table 6).

The typology was obtained from clusters that emerged from the plotted category centroids and their proximity, which is associated with close distances between category centroids (Table 7, Fig. 1). The order of the clusters explained in Table 7 broadly reflects their similarity. However, because clusters were determined from a two-dimensional graph, there are also other ways of interpreting relationships between different types of knowledge exchange evaluation. For example the 'post-positivist (networks)' type is equally close to 'connective' and 'post-positivist (short)' types as it is to 'post-positivist (long)' and 'co-management' types (Table 7,

Table 6
Summary of the non-linear CCA. 'Set' refers to the order in which clusters of variables were added to the analysis.

	Variables added to the set	Dimension		Sum
		1	2	
Set 1	Extent of theory explanation, Who is knowledge exchanged between? Process evaluated?, What outcome dimension is evaluated?	,180	,259	,440
Set 2	The 15 different approaches to knowledge exchange	,284	,194	,478
Set 3	Study Design, Randomisation, Qualitative/Quantitative, Intent of Evaluation, Evaluator, Time of evaluation, Degree of participation, Duration of knowledge exchange	,246	,208	,454
Set 4	The 10 different tools used for data collection	,389	,536	,925
Mean		,275	,299	,574
Eigenvalue		,725	,701	
Fit				1,426

Figure 1). The types of knowledge exchange evaluation are explained below.

3.1.1. Positivist

This type is characterised by one-way exchanges and two traditional approaches to knowledge exchange: teaching, and the distribution of information media (e.g. leaflets). It includes all evaluations that had "before and after" study designs, with some using a control and some comparing different approaches. Evaluations tended to be characterised by a short knowledge exchange duration (less than 1 year) and often deployed knowledge tests for data collection. Evaluations were also more likely to be conducted at the end of a knowledge exchange intervention. Most evaluated only changes in understanding/learning or this in combination with changes in behaviour/practice/policy.

The type indicates that a positivist view of knowledge is held by evaluators. It suggests that knowledge is perceived as an 'item' or discrete 'fact' produced by researchers that can be detached from the producers and distributed by simply informing people. Viewing knowledge in this way makes it relatively easy to perform experimental evaluations, with the success of the knowledge exchange being determined by measuring how much a person holds of a particular item or set of facts. Studies can therefore more easily be randomised, quantified, and assessed after the knowledge exchange has been conducted. The limited focus on the outcome dimension of 'impact' emerging from changes in behaviour/practice/policy is partly because impacts are difficult to measure, but may also be because impacts are assumed to be made automatically as a result of change in understanding or because links have been proven elsewhere.
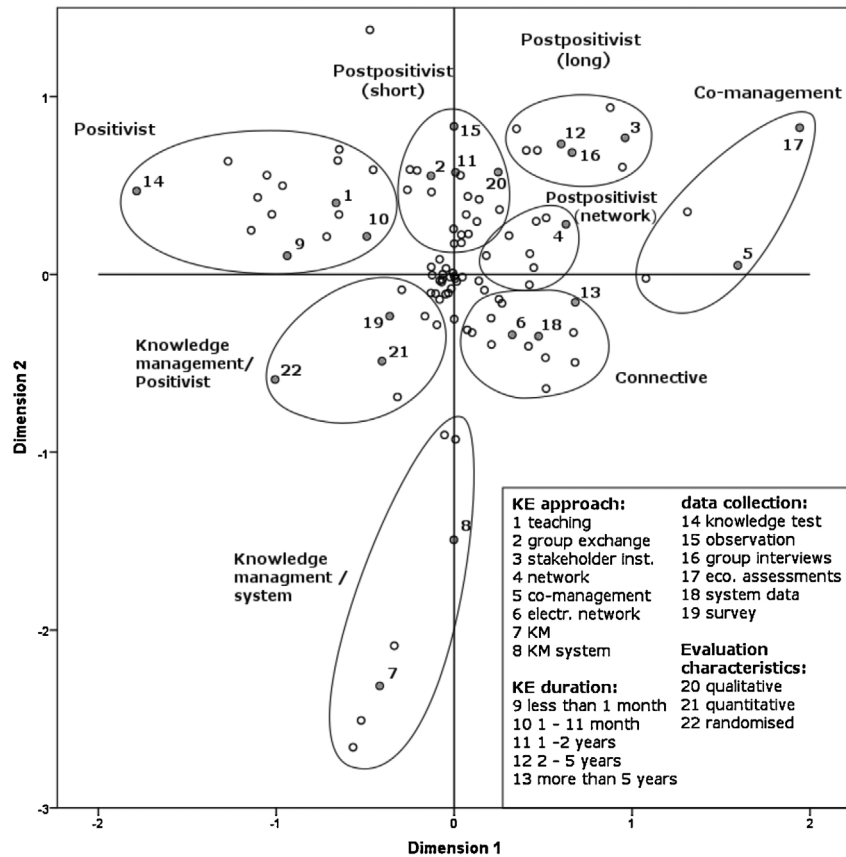
Fig. 1. Relationship between the categories used in the canonical correlation analysis. Each data points relates to a category, not a research paper. Examples of the categories are numbered circles and explained in the key. Clustering of the different categories identifies different kinds of knowledge exchange evaluations and provides the basis of the knowledge exchange evaluation typology.

Table 7

Typology of knowledge exchange evaluation. The typology is determined by examining which categories from Table 2 are most closely associated with each other (i.e. have similar centroid scores). The total number of papers included in each category is shown in brackets. Abbreviations for outcome dimensions are: UN = understanding, PC = practice change, IPC = impact of practice change, PR = process.

	Positivist	Postpositivist (short)	Postpositivist (long)	Postpositivist (networks)	Co-management	Connective	Knowledge management/system	Knowledge management/positivist
Knowledge exchange								
Who is knowledge exchanged between?	R > WS, 1 way (5); PM > WS, 1 way (12); R > PM, 1 way (13)	R > PM, 2 way (21)	R <> PM <> WS 2 way (13)		PM <> WS, 2 way (16)	R <> R, 1 or 2 way (3); PM <> PM 1 or 2 way (8)	WS <> WS 2 way (41); Not specified (1)	
Extent of theory explanation		No explanation (22); Some explanation (43)						Extensive explanation (68)
Approaches to KE	Medium (28); Teaching (38)	Knowledge broker (8); Knowledge champion (6); Group exchange (48); Personal contact (26); Literature (5)	Stakeholder institutions (15)	Network (12); Working partnership (18)	Co-management (9)	Electronic network (27); Observation/Replication (4)	KM system (14); Knowledge management (13)	
Evaluation								
Study design	B&A with control (7); B&A without control (16); CACS with B&A (controlled or not) (11)			One KE only (46); CACS (controlled or not) (34)		One KE with control (3)	Relationsship between KE and other variable (10)	Other (6)
Further characteristics: (Randomisation, qualitative/quantitative, intent of evaluation, evaluator, time of evaluation, degree of participation)	Evaluation at End (52)	Qualitative (48); Intent to improve (40); Internal evaluator (46); Not clear whether external or internal evaluator (4)	Participatory (20)	Non-randomised (112); External and internal evaluators (6); Qualitative and quantitative (28)		External evaluator (78); During (78); During and end (3)		Randomised (21); Quantitative (58); Consultative (16)
Duration of KE	<= 1 month (15); 1–11 months (23)	1–2 years (20)	2–5 years (21)			5 years or more (21)	Not specified (31)	
Tools for data collection	Knowledge test (10)	Observation (30); Interviews (52)	Documentary data (23); Site visits (4); Group interviews (17)		Literature (7); Ecological Assessment (5)	System data (11)		Surveys (76)
Outcome dimensions	Only UN (19); Only PC (2); UN and PC (21)	UN + PC + IPC (15); UN + IPC (9)	PC + IPC (9)			Only IPC (25); Only PR (34)	Only other (3)	

3.1.2. Post-positivist (short, long and networks)

Three 'post-positivist' types of knowledge exchange evaluation were identified. These often involved two-way exchanges with researchers. They also used a wide range of approaches to knowledge exchange, including literature publications, use of knowledge brokers and champions, group exchanges, personal contacts, involvement of multi-stakeholder institutions, networks and working partnerships. The extent to which the underlying concepts or assumptions behind the knowledge exchange were explained was low in this type. Study designs were not randomised, and either described one case study only or compared different case studies and approaches without baseline data. They were more inductive, enabling identification of unanticipated or complex outcomes. Evaluations were more often participatory or formative than other types and used to improve knowledge exchange projects as they unfolded. Evaluators were often part of the project teams and collected or analysed qualitative data or used diverse methods. The duration of knowledge exchange before evaluation (2–5 years) was longer than in the positivist typology, and a wider breadth of outcomes were evaluated. All combinations of evaluated outcomes associated with this typology included impact of policy/practice changes, but sometimes included changes in understanding/attitudes and in behaviour/practice policy. The post-positivist types of knowledge exchange evaluation were differentiated by the duration of the knowledge exchange before it was evaluated (short or long), and by the approach used for knowledge exchange (e.g. partnerships and networks for the 'network' type versus more specific and directed approaches of knowledge brokers in the 'short' type).

These types of knowledge exchange evaluation imply a more relativist view of knowledge, exchange and evaluation where knowledge is considered to be relational, context dependent, and the experiences of knowledge exchange subjective. They result in knowledge exchange approaches that involve more complex interactions and exchanges, recognition that knowledge is not something that is easily transferred, and that researchers are not the sole producers of knowledge but also have something to learn from exchanges. They also imply greater recognition that knowledge exchange is a continual dynamic process, greater tendency for participatory and formative methods of evaluation, and more diverse data collection methods (e.g. participant observation, interviews, and focus groups).

3.1.3. Co-management

This type of knowledge exchange evaluation includes categories related to the concept of co-management (e.g. where multiple stakeholders may be involved in managing a complex integrated social and ecological system). Exchanges tended to be between policy makers and multiple stakeholders. Explanations of how knowledge exchange is performed and the theory behind the process were often lacking.

Co-management types of knowledge exchange evaluation are most closely associated with the post-positivist forms of evaluation. However, they also tended to view co-management as a process of social interaction, which may or may not explicitly include the exchange of knowledge. Emphasis is therefore often placed on understanding the impact of changes in policies and practices, such as indicators of ecological health or fisheries stocks rather than on evaluating learning, behaviour/practice, or the underlying processes of knowledge exchange.

3.1.4. Connective

The knowledge exchange approach in this type of knowledge exchange evaluation was often an electronic network, connecting people over larger distances. This type related to post-positivist (networks), co-management, and knowledge management/system

types due to its use of electronic systems and longer duration of projects that may not have had a clearly defined end point. This is in contrast to positivist and post-positivist (short) types of knowledge exchange evaluation that have a clearly defined beginning and end of a knowledge exchange process, which operated over shorter timescales and may have been specifically set up and led by those leading a research project. As with co-management and knowledge management/systems there is a tendency to focus on impact of changes in policy/practice. In contrast, there is a greater focus on the processes of knowledge exchange.

3.1.5. Knowledge management/systems

The knowledge management/systems type involved exchanges between company employees, members of different organisations, or members of other kinds of stakeholder networks. There was often explicit explanation of the underlying theory to the knowledge exchange. Evaluation designs tended to relate the quality or quantity of knowledge exchange to other impact-related variables (e.g. business performance). The duration of knowledge exchange was rarely specified and where it did, it tended to be very long (>5 years) presumably because knowledge exchange is seen as an ongoing process. The dominant approaches to data collection were surveys. However, although quantitative data were used, they were mostly based on the subjective assessments of managers and other employees completing the surveys.

This typology therefore has a distinct view of knowledge exchange, albeit with similarities to both the positivist and post-positivist views. As in the post-positivist type, knowledge is perceived to be created by many people interacting as equals, enhanced by two-way interactions, and with recognition that people may learn differently. However, as with the positivist view, knowledge may also be considered to be distributed in an inert form separate from an individual or group and exchanged relatively easily. Knowledge exchange is seen as a means to an end, with the mechanism of exchange occurring through improved electronic infrastructure that serves the aims of an organisation. Finally, changes in understanding/learning or changes in behaviour/practices/policy were rarely assessed. Instead, and as with co-management, there was a tendency to focus on impacts of practice/policy.

### 3.1.6. Knowledge management/positivist

An additional cluster was identified which had no evaluations directly related to it. Instead, this cluster reflected characteristics shared by evaluations that are found in the knowledge management/system and positivist types. It shows that both types place emphasis on quantitative data collection, randomisation and viewing knowledge exchange in systemic ways. Unlike the post-positivist view, there is much tendency to explain the underlying conceptual foundations and assumptions of the knowledge exchange process. As in the knowledge management/systems typology, many knowledge management/positivist evaluations relied heavily on surveys.

3.2. Knowledge exchange evaluations in different research fields

In addition to identifying a typology, the analysis organised different papers according to their similarities in approaches to knowledge exchange and evaluation. The results suggest that the way knowledge exchange is conducted and evaluated is strongly associated with different research fields and how knowledge exchange is defined (Figs. 2 and 3). Studies categorised as 'organisational management' or independently described as 'knowledge management' and 'knowledge sharing' tended to be located in lower quadrants of Figs. 1 and 2. 'Health care' or
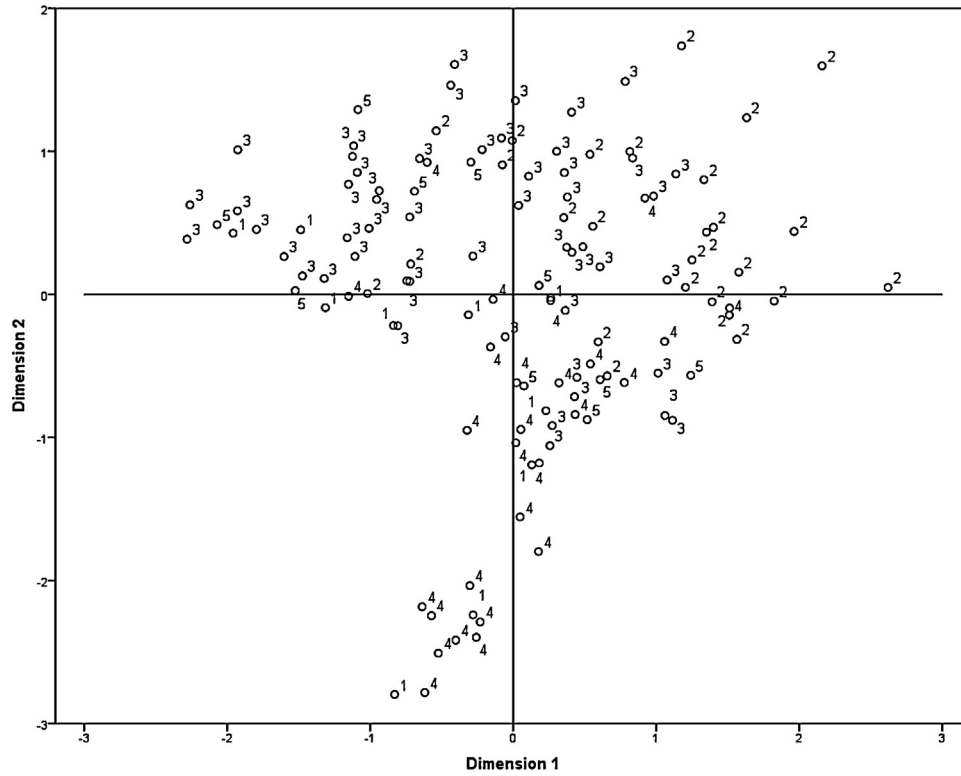
Fig. 2. Object scores for each paper derived from the non-linear canonical correlation analysis labelled according to the research field the paper is from. Each data point refers to a single paper. Data points are: 1 = education; 2 = environmental management; 3 = health care; 4 = organisational management; 5 = other. The dimensions are derived from the non-linear canonical correlation analysis, which reduces the variables to two non-correlated significant underlying factors.
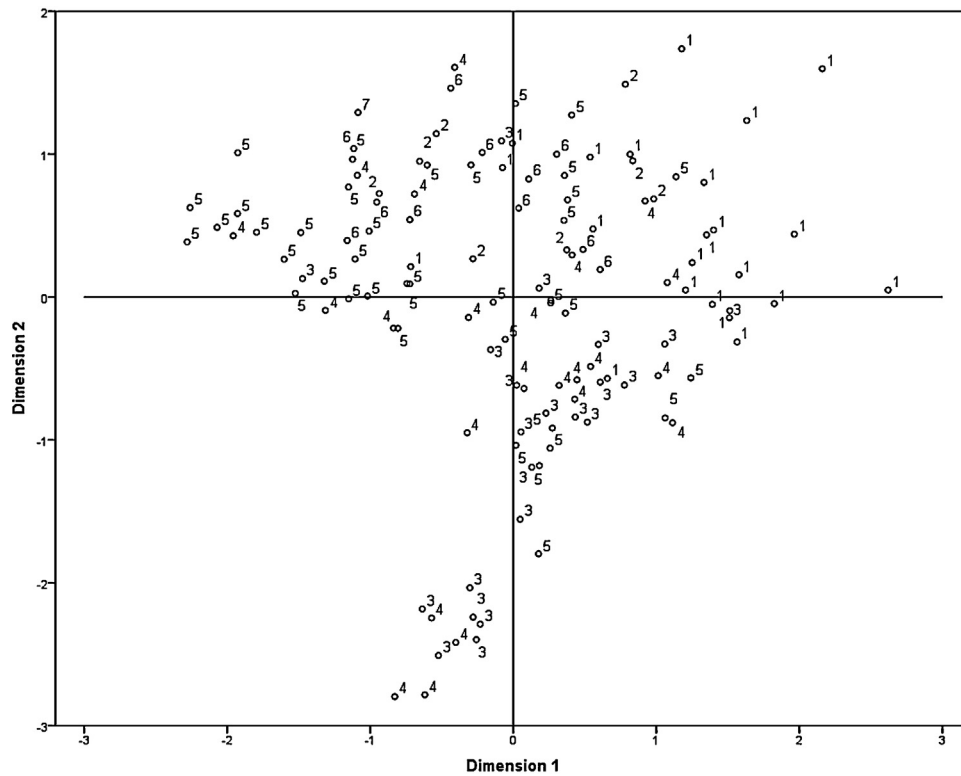
Fig. 3. Object scores for each paper derived from the canonical correlation analysis labelled according to the search term that identified the paper. Each data point refers to a single paper. Data points are: 1 = co-management; 2 = knowledge exchange, 3 = knowledge management, 4 = knowledge sharing, 5 = knowledge transfer, 6 = knowledge translation, 7 = co-production + knowledge. The dimensions are derived from the non-linear canonical correlation analysis, which reduces the variables to two non-correlated significant underlying factors.

'knowledge transfer' were in the upper left quadrants, and 'environmental management' or 'co-management' in the upper right quadrants. Finally, the small number of studies from education were found mostly in the upper and lower left quadrants and tended to be associated with the terms knowledge 'management' or 'sharing' (Figs. 2 and 3). The terms used to define knowledge exchange imply different ways of conceptualising knowledge exchange. For example, 'transfer' implies knowledge is portable, has a linear direction, with delivery and reception in a one-way process. 'Exchange' on the other hand implies a two- or multiple-path process with reciprocity and mutual benefits, possibly with multiple learning (Fazey et al., 2013). The tendency for different fields to use certain terms to define knowledge exchange therefore suggests that different cultures and traditions influence or are influenced by the way knowledge exchange is conceptualised, delivered and evaluated.

Knowledge exchange and its evaluation in the different disciplines are also broadly associated with the different types of knowledge exchange evaluation. Health care tended to have large numbers of studies associated with positivist types. The field therefore can make significant contributions to understanding how to deliver experimental forms of evaluation on relatively specific short-term projects (Cashman et al., 2007; Kirshbaum, 2008). While there are excellent examples of larger scale and complex evaluations from the healthcare (Blanton et al., 2010; McWilliam et al., 2005; Rycroft-Malone et al., 2011), it has been suggested that the largely positivist, evidence-based approach applied in this field discourages more holistic forms of knowledge exchange (Kothari et al., 2011a). Particular views of what is perceived to count as "good evidence" therefore appear to structure both evaluations and the kinds of knowledge exchange delivered.

Many of the studies from environmental management are associated with a post-positivist or co-management type of knowledge exchange evaluation. Studies tended to include two-way exchanges, often between policy makers, wider stakeholders and/or researchers with experimental positivist approaches generally being limited to meta-analyses of multiple projects (del Pilar Moreno-Sánchez and Maldonado, 2010; Evans et al., 2011; Gutierrez et al., 2011). Environmental management can therefore provide useful insights for evaluations of multi-way exchanges, and formative styles of evaluations (Kuper et al., 2009; Muñoz-Erickson et al., 2010). It would, however, benefit from more robust methods (e.g. comparative approaches) and being much more explicit about the underlying conceptual thinking as to how the knowledge exchange process is expected to deliver key outcomes. This is especially the case for research on co-management which rarely provided details of how co-management occurred or what the authors meant by the term.

Organisation management focused on managing knowledge and the systems designed to achieve this (Cricelli and Grimaldi, 2010), with most studies being associated with the knowledge management type of knowledge exchange evaluation. For example, evaluations were dominated by exchanges between a wide range of stakeholders (e.g. within and between organisations) and studies more often included detailed explanation of underlying theory of knowledge and knowledge exchange than other fields (e.g. Cantú et al., 2009; Marra, 2004). Organisation management can therefore make significant contributions to understanding evaluation of approaches that aim to engage multiple participants, and for demonstrating how to be more explicit about conceptual underpinnings and assumptions of the knowledge exchange approach. It would, benefit from greater attention to participatory and formative styles of evaluation to enhance ongoing improvement of the systems used to deliver knowledge exchange (Kothari et al., 2011a).

Finally, the small number of studies from education was associated with the positivist or knowledge management types of knowledge exchange evaluation. Many studies included detailed description of the underlying theories of knowledge exchange and often involved knowledge exchange between practitioners and wider stakeholders. Studies tended to have high degrees of randomisation, and quantitative analysis, and to be focused on short-term projects. Data collection was through surveys, with the majority focusing on the processes of knowledge exchange.

4. Discussion

This study, which is the first empirically based interdisciplinary analysis of knowledge exchange evaluations, shows there are strong relationships between conceptualisations of knowledge and knowledge exchange, how knowledge exchange is implemented and evaluated, and the field of research. Thus different research fields tend to view knowledge and knowledge exchange in different ways, resulting in different approaches to knowledge exchange and evaluation methodologies. This diversity both poses significant challenges and opportunities for global change research, which encourages co-production and co-management styles of knowledge exchange (Connick and Innes, 2003; Raymond et al., 2010) and brings together multi-stakeholder groups with different values and ontological and epistemological perspectives (Fazey, 2010; Hofer, 2000; Miller et al., 2008)

A challenge for global change researchers is to be much more cognisant of how their perspectives on knowledge affect the design of knowledge exchange and its evaluation. The impact of these perspectives is demonstrated by the empirically derived typology presented in this paper. Different search terms to identify evaluations or survey questions are likely to have influenced the results, while relying on published research is likely to poorly represent certain forms of knowledge exchange (e.g. exchange that occurs through the media or in workshops). Nevertheless, validity of the typology is confirmed by its similarity to more general conceptually founded classifications of evaluation. This includes the four different 'realms' of evaluation: positivism, post-positivism, pragmatism (which emphasises truth as being 'what works for now') and 'constructivism' (where knowledge is believed to depend on the knowers' frames of reference) (Guba and Lincoln, n.d., in Chapman et al., 2007). It also includes Reeves' (1997) classifications, which also identified a positivist type (called the positivist-quantitative paradigm) and three divisions of the post-positivist type identified in this study. These are (1) the constructivist-interpretive-qualitative paradigm (which seeks to understand social constructions and focuses on social interactions and multiple perspectives), (2) the critical theory-postmodern paradigm (which is descriptive, but also aims to create change through theory and reflection), and (3) the eclectic-mixed methods-pragmatic paradigm (which involves complex evaluation strategies and focuses on practical problems). Our typology, which is specific to knowledge exchange evaluation, provides a valid and useful frame of reference to assist discussions about what is meant by knowledge exchange and underlying assumptions when developing knowledge exchange and evaluation approaches.

A secondary challenge is that while there are multiple ways of doing evaluations, many of the studies identified in this paper fell short of dealing with the complexities of multi-stakeholder and interdisciplinary knowledge exchange endeavours. Many evaluations only address specific and short term one-way exchange interventions, and/or evaluate relatively few outcome dimensions. This reflects relatively simplistic notions of how knowledge is exchanged and how people learn. Knowledge exchange rarely works in the ways often portrayed in dissemination activities emerging from evidence-based approaches, even when considerable efforts are made for these to work (Gabbay et al., 2003). Instead, decision-making is socially determined. It involves

dynamic patterns of collective sense-making that include tacit and experiential knowledge, interpretation of new knowledge and negotiation of its meaning, and collective processing of knowledge influenced by group dynamics (Gabbay et al., 2003; Nonaka et al., 2000). There are, however, a growing number of conceptual and empirical papers that outline the evaluations needed for multi-stakeholder exchanges of knowledge (Connick and Innes, 2003; Meagher et al., 2008; Pahl-Wostl, 2009; Plummer and Armitage, 2007). These studies highlight a need for more sophisticated evaluations where knowledge exchange is perceived to be continual, iterative and synthetic (Kuper et al., 2009; Olson et al., 2010).

While many evaluations used methods inappropriate for interdisciplinary endeavours, there were some positive findings. Many assessed at least some aspect of the knowledge exchange process, and there are examples that assess a wide diversity of outcomes. As indicated in the results, different research fields have distinct strengths from which other fields can learn. These include strengths in experimental approaches and examples of large scale and participatory evaluations in healthcare; strengths in understanding knowledge systems and examples of conceptualising knowledge and knowledge exchange from organisational management; and insights into delivering knowledge exchange activities involving multi-stakeholder groups and projects operating over relatively long periods. The cumulative lessons from the papers analysed in this study are presented below as five overarching principles to guide evaluation of knowledge exchange.

4.1. Principles for knowledge exchange evaluation

A catch-all method for evaluation is neither possible nor desirable. The principles are therefore intended to be a broad guide rather than be a comprehensive prescription. The principles focus thinking on the design of evaluations of knowledge exchange in interdisciplinary and/or multi-stakeholder research projects aiming to enhance understanding of, and to develop solutions to, complex issues about global environmental change.

4.1.1. Design evaluations for multiple end users

Even though many knowledge exchange activities aim to enhance co-production of knowledge, there are diverse perspectives on what constitutes a useful outcome of knowledge exchange. For example, research funders place greater emphasis on efficiency of returns on investment (i.e. accountability) or on socio, economic or environmental outcomes; research providers on rigour (because their reputation and promotion largely depend on this); and users of research focus on the relevance of the outcomes of knowledge exchange and the knowledge shared (Roux et al., 2010). If the evaluation aims to enhance stakeholder learning through interactions between community partners and researchers, then it needs to recognise that community partners have their own priorities, and expertise. It must actively build confidence of community partners in researchers and research (Bowen and Martens, 2006). Further, evaluations can invoke mistrust or resistance when they are perceived as a form of control aimed at exposing failures of those implementing research projects and programmes. Such perspectives tend to emerge in contexts where mistakes are not tolerated, or where demands for external accountability are high, which limit opportunities for learning (Rushmer et al., 2004). Careful attention is therefore needed to cater for these subtle but important differences between users of evaluations, and to be sensitive to the way an evaluation is presented and its findings used.

4.1.2. Be explicit about how knowledge exchange is conceptualised and the assumptions as to why it is expected to deliver its outcomes

The results highlight strong inter-dependencies between the way knowledge exchange is conceptualised, delivered, and the approaches and methods used to evaluate knowledge exchange. Clarity is therefore needed about how knowledge and knowledge exchange are conceptualised and the assumptions as to why a particular knowledge exchange approach or intervention is expected to deliver its outcomes. Identifying assumptions behind interventions is considered to be one of the most important issues in evaluation design (European Communities, 2006). This includes being explicit about why knowledge exchange is necessary (the intervention rationale) and the assumptions as to why a particular knowledge exchange processes is believed to deliver expected outcomes (the intervention logic). The former enables the evaluation to be targeted towards the objectives of knowledge exchange; the latter provides the basis for identifying evaluation questions and indicators (European Communities, 2006).

The assumptions as to why knowledge exchange was expected to deliver its outcomes were often not explicit in the papers analysed in this study. To improve clarity, and in addition to considering the typology of knowledge exchange evaluation provided by this study, use can be made of tools such as logframes and 'theory of change' (TOC) (Andersen, 2005; Schmidt, 2009). TOC is particularly useful because it is designed for change-making activities in complex settings and includes a process for identifying links between activities and outcomes, and for explaining how and why the desired change is expected to occur (Andersen, 2005). It is especially useful where changes in human behaviour are complex, and where there are high degrees of subjectivity in relation to the problem focus and potential solutions. Overall, the close synergy between conceptualisation of knowledge and knowledge exchange and evaluation, points to the importance of developing evaluation methods in tandem with the design of knowledge exchange processes. This forces greater attention on why and how a knowledge exchange approach is expected to generate the desired results.

4.1.3. Evaluate diverse outcomes

Knowledge exchange is a complex, dynamic and context specific process. Evaluations therefore need to consider a diversity of outcomes. There are, however, particular challenges in measuring outcomes of large interdisciplinary studies where success can be multidimensional, subjective and difficult to define (Clark et al., 2008). Ideally, indicators should represent a negotiated agreement of all stakeholders, reflect social rather than individual activity, and address key criteria such as being recognisable, achievable, describable, tangible, and relevant (Dixon and Sindall, 1994).

Understanding knowledge exchange and its impacts also requires particular focus on process-oriented outcomes (Connick and Innes, 2003; Meagher et al., 2008). Formative rather than summative styles of evaluation are more useful in this regard because they are more able to analyse why outcomes emerge and the relative contribution of knowledge exchange to outcomes. This includes understanding the timeliness, access, relevance, and utility of knowledge exchange interventions and influence of other factors, such as social processes, group dynamics, legislature and institutions (Gabbay et al., 2003; Heylings and Bravo, 2007; Meagher et al., 2008; Morton, 2012; Olson et al., 2010; Phillipson et al., 2012). Understanding the quality as much as the quantity of knowledge exchange outcomes is also important (Connick and Innes, 2003). For example, collaborative ventures with multi-stakeholder interests can produce agreements but not necessarily agreements of quality (e.g. whether they are long-lasting and useful). Quality agreements only emerge when there has been considerable focus on social processes that build trust, mutual respect and collaborative capacity (Connick and Innes, 2003; Kuper et al., 2009), emphasising the need for knowledge exchange to focus on building social capital rather than using standard technological tools for knowledge exchange (McWilliam et al.,

2005). Evaluation is also embedded in overlapping spheres of influence, from local considerations, institutional needs and regional issues that influence the knowledge exchange and focus of evaluations (Stokols et al., 2008). Knowledge exchange evaluators therefore need to be aware of the politics of power in which they are embedded and may inadvertently influence (Fazey et al., 2013).

This raises important questions about whether the focus should be on evaluating the process of knowledge exchange or the 'impact' of knowledge exchange or research. While evaluating knowledge exchange is closely related to evaluating impact (Molas-Gallart and Tang, 2011), there are subtle differences. Evaluating knowledge exchange has particular emphasis on understanding processes that enhance knowledge sharing in ways that generate impact, whereas evaluating impact can involve greater focus on the outcomes of such processes without necessarily understanding why these outcomes occur. Multi-stakeholder, interdisciplinary and integrated research and practice endeavours are complex and usually involve long time lags between research activities and associated impacts (Phillipson et al., 2012; Plummer and Armitage, 2007). There are also challenges in establishing linear relationships between implementing knowledge exchange and longer term outcomes or impact, and teasing out the relative influence of the implementation of knowledge exchange from the often powerful political, economic, social, cultural and institutional factors that affect longer term outcomes (Davies et al., 2005; Phillipson et al., 2012). Processes and outcomes are not easily separated (Innés and Booher, 1999). However, by concentrating at least as much effort on understanding the processes of knowledge exchange involved in generating impact as much as the impacts per se it is possible to provide more immediate feedback to enhance delivery of knowledge exchange, increasing the likelihood that long-term impacts will be achieved (Meagher et al., 2008). Irrespective of whether the focus is on evaluating impact or knowledge exchange, the message remains the same: it is important to be clear about the outcomes being evaluated and to have a robust strategy for doing so (Bellamy et al., 2001) and to understand why observed outcomes occur and the quality of those impacts.

4.1.4. Use evaluations as part of the process of delivering knowledge exchange

Involving stakeholders in the process of designing and implementing evaluations of knowledge exchange can be an active part of the knowledge exchange strategy itself. Participatory evaluations require participants to actively consider and be explicit about the objectives and desired outcomes of the knowledge exchange they are involved in. This results in wider and deeper learning about the knowledge exchange process (Heylings and Bravo, 2007; Zukoski and Luluquisen, 2002). Participation also enhances ownership and responsibility for the knowledge exchange process, clarifies roles, and can facilitate discussions about different perspectives of knowledge and its exchange (Fetterman and Wandersman, 2005). Carefully designed and managed participatory evaluations become powerful tools for enhancing knowledge exchange, encouraging people to wrestle with epistemological differences and their assumptions. Such evaluations are useful for interdisciplinary endeavours that genuinely aim to build social relations. Participatory evaluations are usually formative, enabling greater learning and flexibility as new insights emerge. As in participatory forms of development, however, benefits may be curtailed if project directors or funders are not responsive to findings (Bowen et al., 2005; Parfitt, 2004). Not all evaluations need to be participatory, and considerable resources may be needed to enhance participation (Zukoski and Luluquisen, 2002). Yet they are particularly useful for helping instigate change when change is desired.

4.1.5. Use mixed methods

Mixed method approaches, comparative case studies, and multi-tiered evaluations that combine information arising from specific knowledge exchange activities with larger scale and longer term processes are most useful for evaluating knowledge exchange (Bell et al., 2011; Bowen and Martens, 2006; McWilliam et al., 2005; Waters et al., 2011). Qualitative methods have the advantage of 'identifying intangible factors' and are capable of capturing social aspects of knowledge exchange, such as 'culture, behaviour, practice, opinion, and experience'. Quantitative approaches can measure explicit knowledge and its relationship to success or performance outcomes (Kuah and Wong, 2011). Qualitative approaches may be more important for understanding why knowledge exchange occurs and may therefore be more relevant than quantitative measures (Bowen and Martens, 2006). Further, qualitative approaches provide greater local control over the research, can integrate input from diverse sources, and enable searching for meaning and patterns in ways that do not preclude circumstances which may at first sight appear to be random or contradictory (Dixon and Sindall, 1994). Nevertheless, quantitative measures can play a significant role in providing insights into the patterns of exchange that occur in large knowledge exchange and research programmes and for tracking interactions over time through provision of longitudinal data (McWilliam et al., 2005; Phillipson et al., 2012). Authors who have addressed particularly complex interventions highlight that both quantitative and qualitative approaches are important, with the value of qualitative approaches often being overlooked (Bowen et al., 2005; McWilliam et al., 2005). Both deductive and inductive approaches are also needed to ensure unanticipated outcomes and processes involved in knowledge exchange can be identified. While tailored multi-method approaches are necessary, evaluations also need to be practical and maintain a balance between sophistication and application of appropriate levels of resourcing (Bell et al., 2011).

5. Conclusions

Interdisciplinary and multi-stakeholder interaction in environmental change research actively involves social interaction and exchange of knowledge. Greater attention to the design and management of such processes is needed if they are to result in innovative and practical solutions to the challenges of global change (Connick and Innes, 2003; Pahl-Wostl, 2009). While emphasis on knowledge exchange in global environmental change research and environmental management is increasing (Phillipson et al., 2012; Reed et al., 2014), it is often considered as an afterthought with limited acknowledgement of the high level of expertise necessary for the effective design, facilitation and implementation of such activities (Reed, 2008). Importantly, learning how to do knowledge exchange better is limited by lack of structured and coordinated evaluations (Bellamy et al., 2001; LWEC, 2012). Well-designed evaluations of knowledge exchange therefore need to be routinely embedded in interdisciplinary and multi-stakeholder environmental change research and knowledge exchange activities.

While summative evaluations have a role to play, if the aim is to learn how to improve knowledge exchange or to understand how knowledge exchange processes contribute to policy or practical impacts arising from research, then formative approaches that focus on understanding process oriented outcomes will be most useful. Further, participatory evaluations have the added value of providing opportunities to encourage participants to reflect on how their underlying assumptions of knowledge exchange and the quality of social interactions influence meaningful exchange and integration of knowledge. Addressing global environmental challenges, however, is much more than just about providing

better information and reducing environmental impacts. It is also about achieving just and equitable societies. Social disparities are heavily influenced by how certain kinds of knowledge are privileged over others, and knowledge exchange processes and evaluations will always affect how different kinds of knowledge are perceived. Given the strong associations between how knowledge is conceptualised, conducted, and evaluated, interdisciplinary researchers and those evaluating knowledge exchange therefore need to bear in mind that their evaluation methodologies may equally shape the way in which different voices are heard.

Acknowledgements

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2013.12.012.

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